Granular-Fluid Interactions Near the Seabed

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LONG-TERM GOALS

Our long-term goal is to develop a model that will predict local sand transport and bathymetric change due to waves and currents under time-varying conditions.

OBJECTIVES

Accomplishment of the long-term goal will require significant improvement of our understanding of the relationships between hydrodynamics and sediment motion near the seabed, as well as the development of models derived from our understanding of the relevant physical processes. This requires coupling between hydrodynamic forcing, bedform response and feedback, bedload sediment transport response, and the suspended sediment response.

APPROACH

Model development is being pursued in combination with the analysis of observations obtained in the field and in large-scale laboratory facilities. Observations of bedforms, nearbed suspended sediment, and hydrodynamics provide a basis for the discovery of phenomena that will be incorporated into the development of models. We are focusing on the small-scale dynamics of turbulence and suspended sediment in the vicinity of bedforms, the coupling of bedload and suspended load, and a theory for bedload sediment transport based upon granular mechanics.

WORK COMPLETED

We have analyzed the bedform dimensions from the Sandyduck97 and SISTEX99 data sets. The bedform observations from Sandyduck97 have been combined with previous observations and has been accepted for publication. An improved method of resolving short wave ripples from MTA data has been developed.

Particular data runs from Sandyduck97 have been analyzed with respect to the distribution of suspended sediment over long wave ripples. The measured bedforms and hydrodynamics have been used as input to drive the Dune2d numerical model of the bottom boundary layer.

Three methods of estimating turbulence from ADV measurements have been applied to the data sets.

Sandyduck97 measurements have been examined to evaluate the relationship between turbulence intensity and suspended sediment concentration.

Pressure gradient and bed-slope terms have been added to the kinetic bedload model of Jenkins and Hanes (1998).

RESULTS

The vertical distributions of suspended sediment concentration were investigated over low amplitude long wave ripples in four different data sets with comparable hydrodynamic conditions and with the sediment concentration measurements at relatively different cross-shore locations over the bedforms. The concentration profiles exhibit different temporal patterns that relate to their different locations over the bedforms, as shown in figure 1. In figure 1 the upper panels show the ensemble average of the cross-shore fluid velocity and the ensemble average of the depth integrated suspended sediment concentration. The lower panels show the ensemble average of the vertical distribution of suspended sediment as a function of the wave phase. Though the ensemble averaged velocities show similar patterns for both cases, the distributions of the SSC are very different. In Case (A) the concentration peak occurs near the time of maximum onshore velocity (after the offshore to onshore flow reversal) and then the SSC decreases over the rest of the wave period. In Case (B) the peak of the concentration occurs near the time of offshore to onshore flow reversal. The difference in the timing of the peak concentration related to flow reversal may be understood by considering the SSC measurement location relative to the ripple crest location.

Figure 2 shows the quantity of sediment in suspension compared to the turbulent kinetic energy for a large number of measurements from Sandyduck97. In this figure the suspended sediment is characterized by the first moment of the concentration with respect to distance above the seabed, which represents the potential energy of the suspended sediments. The high correlation of 0.85 suggests that there is a strong linkage between the TKE and the potential energy of the suspended sediment.

Other numerous results are evident in the publications listed below, but cannot be described here because of space constraints.

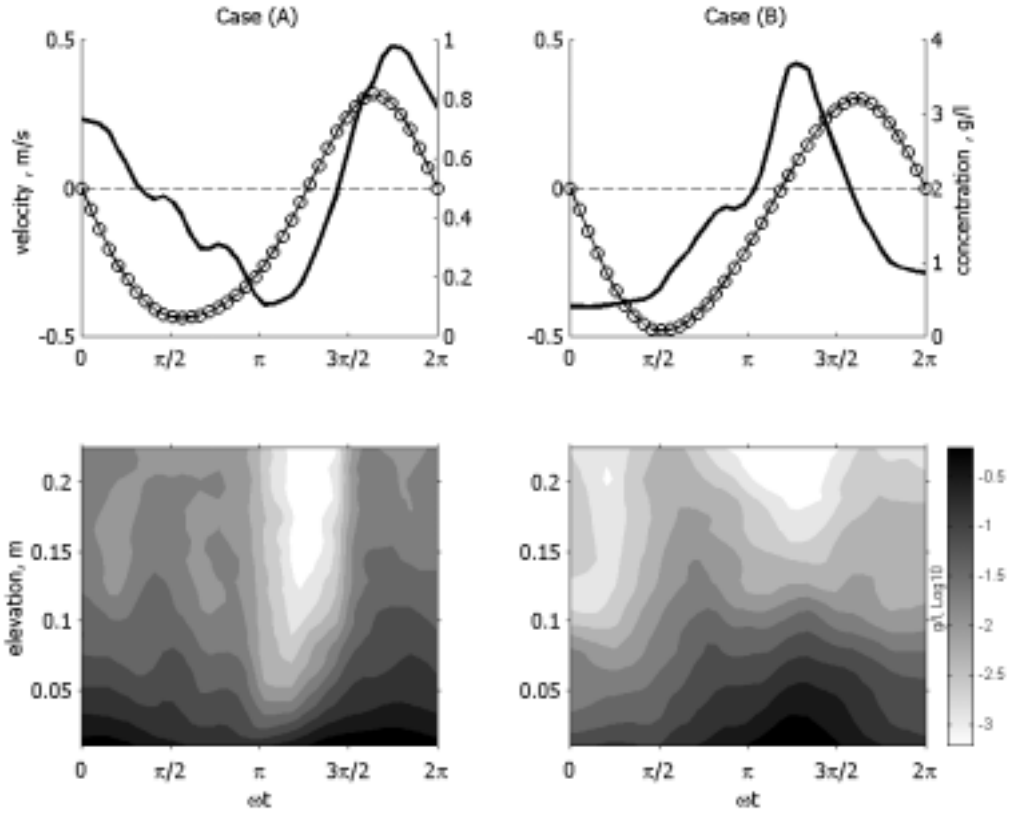

Figure 1: Ensemble averaged horizontal velocities (o), vertically integrated SSC (line, upper panel) and the vertical distribution of the SSC (lower panel).

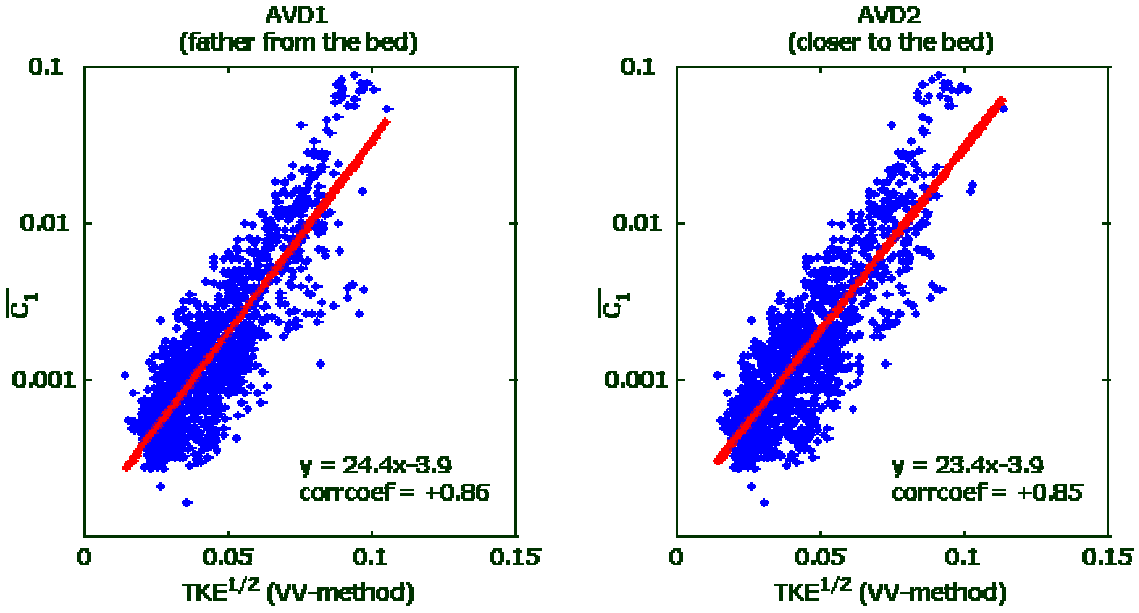

Figure 2: The suspended sediment concentration is highly correlated to the turbulence in these measurements obtained at the Sandyduck97 experiment.

IMPACT/APPLICATION

The connections between small scale and large scale sedimentation processes are important in order to develop a comprehensive understanding of nearshore sedimentation processes, and an ability to model bathymetric change. Our research provides new information on small-scale processes that will allow these connections to be discovered and verified.

TRANSITIONS

Our work on the small-scale dynamics of nearshore sediment transport will be applied in a related project (see below) to develop a general model for local sediment transport in the nearshore region.

RELATED PROJECTS

1) As a part of a NICOP, we have deployed our littoral sedimentation processes measurement system in SISTEX99, in Summer, 1999. In this experiment we worked with Chris Vincent, Marjolein Dohmen-Janssen, and Steve McLean to investigate the small-scale dynamics of bedload and suspended sediment dynamics in a large wave tank. A separate annual report is being submitted for the NICOP.

2) We are working with the NOPP to develop a comprehensive numerical model for the nearshore region. Our main contribution is in the area of sediment transport modeling. A separate annual report is being submitted for the NOPP.

3) In a project funded by Sea Grant, we are studying the hydrodynamics of rip currents using a mobile data collection system designed around a personal watercraft.

4) In a project funded by NASA we are investigating the dynamics of wind blown sand in relation to desert dunes.

PUBLICATIONS

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